CS C191 – Quantum Information Science and Technology Syllabus

Chapter numbers refer to “Quantum Computing: A Gentle Introduction”, by E. Rieffel & W. Polak

01/22 - 01/24 Week 1 (Chap. 2)

- Key concepts of Quantum mechanics illustrated by 2-slit experiment: particle/wave duality, effect of measurement on quantum state, role of uncertainty principle,
- 4 postulates of quantum mechanics
- Quantum states as vectors in Hilbert space, ket and bra notation, inner product, operators (brief)
- Superposition principle, finite dimensional Hilbert spaces
- Measurement principle, Qubits, physical realizations, Bloch sphere, QKD 1

01/29 - 01/31 Week 2 (Chap. 3, Chap. 4)

- Unitary evolution, no cloning
- Multiple qubits, tensor products, entanglement, QKD 2
- Measurements, Bell inequalities

02/05 - 02/07 Week 3 (Chap. 5)

- Unitary transformations, quantum gates, simple applications (superdense coding, teleportation)
- Electron in magnetic field, rotating wave approximation

02/12 - 02/14 Week 4 (Chaps. 6, 7)

- Quantum circuits, universality, circuit simulation (Solovay-Kitaev)
- Reversible computation, arithmetic functions, circuit complexity
- Quantum parallelism

02/19 - 02/21 Week 5 (Chap. 7)

- Quantum-classical separation, quantum supremacy, complexity classes
- Small algorithms, quantum subroutines
- Quantum Fourier Transform

02/26 - 02/28 Week 6 (Chap. 8)

- Shor’s algorithm for factoring
- Quantum phase estimation

03/05 - 03/07 Week 7 (Chap. 9)

- **Midterm 1: Tuesday, March 5**
- Grover’s algorithm

03/12 - 03/14 Week 8 (Chap. 10)

- Mixed states, density operators

- Open systems, decoherence and dephasing, qubit error models

03/19 - 03/21 Week 9 (Chap. 10, Chap. 11)

- Superoperators, Kraus maps
- Classical and quantum error correction codes

03/26 - 03/28 Week 10 Spring break

04/02 - 04/04 Week 11 (Chap. 11, Chap 12)

- Quantum error correction with stabilizer formalism
- Fault tolerance, threshold theorem

04/09 - 04/11 Week 12 (Chap. 13)

- **Midterm 2: Tuesday, April 9**
- Other techniques for error suppression and avoidance

04/16 - 04/18 Week 13 (Chap. 13)

- Alternative paradigms for quantum computation - cluster state and adiabatic quantum computation
- Hybrid quantum-classical computation for near term machines

04/23 - 04/25 Week 14 Project Presentations

04/30 - 05/02 Week 15

- Quantum simulation
- Physical implementation of quantum computers